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FILMING

2001 A SPACE ODYSSEY

By HERB A. LIGHTMAN

During my last trip to London a year and a half ago arrangements were made for me to meet with producer-director Stanley Kubrick who was at M-G-M's Borehamwood studio working on his futuristic Super-Panavision spectacle, "2001: A SPACE ODYSSEY". I was looking forward to talking with him and perhaps standing by during the filming of a scene or two of this production, which was being filmed in great secrecy but which had already become a kind of legend among those working on it.

On the morning of the day set for our get-together, I received a call from Kubrick's secretary. It seemed that he had encountered a crisis in the cutting room which would keep him tied up for the entire day. Would it be all right if we switched our appointment to the following day, she wanted to know. Unfortunately it wouldn't, because I was scheduled to leave England the next morning.

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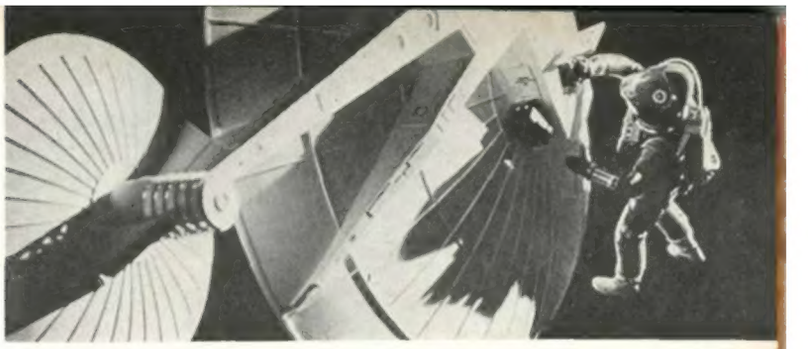
MGM's cosmic spectacular provides a dazzling display of special effects and cinematography, a spellbinding entertainment and a tour de force for Producer-director Stanley Kubrick



In the cold beauty of outer space a 21st Century astronaut works to repair an antenna of the giant spacecraft Discovery.

The upshot was that I didn't get a chance to talk with him in depth about the production until after I had sat enthralled through a preview screening of the final cut. I was stunned by the scope and sheer visual beauty of this 70mm filmic excursion into the future, by the magnificent photography of Geoffrey Unsworth and John Alcott, by the technical perfection of its multitude of enormously complex special effects—but most of all by the uncompromising dedication of the creative genius who had devoted four years of his life and unstinting effort to the realization of this dream on film. Listening to him tell about how it was made, I found myself caught up by his enthusiasm, and tremendously impressed with the wealth of creative imagenation which had been required to put it onto the screen.

"2001" is no mere science-fiction movie. In truth, to be really accurate, it is more like "science-fact" simply extended a few decades into the future. In his quest for complete authenticity in terms of present and near-future technology, Kubrick consulted constantly with more than 30 technical experts and the results, with the possible exception of an "up-tight" computer, are an accurate forecast of things to come.

A Story Far Our In Time and Technique

In order that the enormity of the challenge may be fully appreciated, it is necessary, briefly, to synopsize the story of the film.

MGM presents
A Stanley Kubrick Production
2001: A SPACE ODYSSEY
in Cinerama®
Super Panavision® and Metrocolor

Directed and produced by . . . . . Stanley Kubrick
Screenplay by . . . . . Stanley Kubrick, Arthur C. Clarke
Director of Photography . . . . . Geoffrey Unsworth
Additional Photography . . . . . John Alcott
Production Design . . . . . Tony Masters, Harry Lange, Ernie Archer
Editor . . . . . Ray Lovejoy

All Special Photographic Effects Designed and Directed by MR. KUBRICK

Special effects supervisors . . . . . Wally Veevers, Douglas Trumbull, Con Pederson, Tom Howard
Wardrobe . . . . . Hardy Amies

The picture opens with an awesome prologue entitled "*The Dawn of Man*" in which apelike pre-humans are seen (during an era occurring 4,000,000 years ago) in action against spectacular natural backgrounds. Out of this rugged terrain there arises one morning a smooth, black, rectilinear monolith which first frightens the ape-men and then attracts them.

The time of the film then flashes forward to the year 2001, A.D. A United States envoy is sent on a secret mission to the moon to investigate a strange "made" object uncovered in an excavation of the crater Tycho. It turns out to be the same large monolith which we have seen in the previous sequence—except that now it is emitting a high-pitched signal apparently beamed at the planet Jupiter.

It is decided to send an immense spacecraft, the Discovery, to Jupiter for purposes of investigation. The gigantic vehicle is manned by two superbly self-controlled

Director of Photography Geoffrey Unsworth (center) explains his ideas for lighting the fully enclosed giant centrifuge set. Unsworth's cinematography has a crisp, frosty quality that adds a unique and appropriate extra dimension to this voyage into the unknown. He was faced with, and solved, many photographic problems rarely encountered in every-day terrestrial films.

Keir Dullea, playing a Jupiter-voyaging astronaut, stares in wonder as he peers into a world of "psychedelic" fantesy. The audience does likewise. The last two reels, a riot of flashing symbolism, are farther out than most LSD "trips," and involves several technical processes that were developed especially for this film.

young astronauts (played by Keir Dullea and Gary Lockwood), with a back-up crew of three others resting in a state of quick-frozen suspended animation within "hibernaculums" that resemble mummy cases. The sixth personality aboard the spacecraft is an almost-human computer named HAL that talks in a dreamy voice and ultimately goes off the neurotic deep-end.

The main area of the *Discovery* is a huge centrifuge which rotates at the rate of three miles-per-hour to nullify the weightless effect by means of artificial gravity. Inside their space-age ferris wheel the astronauts do their roadwork and casually walk upside down.

When HAL makes an error in mechanical judgment, the astronauts decide to disconnect all but his most basic functions. However, the computer discovers the plot and, in a fit of all-too-human self-preservative frenzy, kills one of the astronauts when he goes outside of the mother ship to make repairs, executes the deep-frozen trio in their sarcophagi by cutting off their life support, and attempts to prevent the remaining astronaut from re-entering the *Discovery*. This plot is foiled when the cool young man, caught outside without his helmet, blasts his way through the vacuum of space into an air-lock of the mother ship.

With almost surgical objectivity he then proceeds to lobotomize the rebellious (and now contrite) computer by pulling out its "brain cells" one-by-one. Left as the sole survivor, he steers his course toward Jupiter. Approaching the huge planet he is drawn into a vortex of "psychedelic" color, rushing geometric corridors of infinite length

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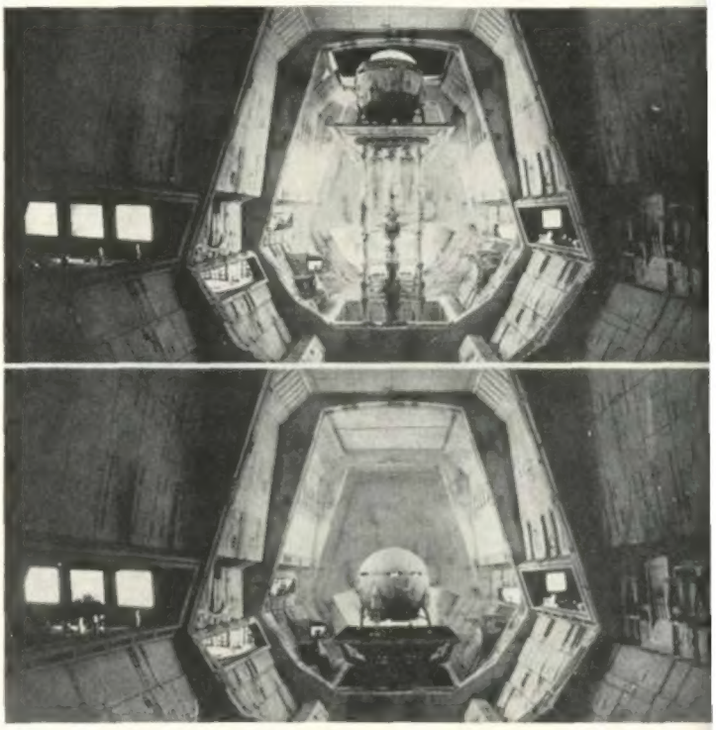
The Aires spacecraft is lowered on a huge hydraulic lift into an air-lock, past huge pressurized ports in which people can be seen moving about. The intricate miniature model had a verical projector aimed through its top to put astronauts in the driver's seat.



STANLEY KUBRICK, producer-director of the MGM presentation, "2001: A SPACE ODYSSEY," was born in New York City, a doctor's son. He was earning money with a camera at an age when most boys are still carrying around their schoolbooks. Look Magazine bought a photograph he took when he was sixteen—a picture registering the grief of a news-vendor amid headlines announcing President Roosevelt's death.

The magazine bought other photo-features, then hired young Kubrick the moment he left Taft High School. He was soon a precociously successful photo journalist. But pictures had to move to give him satisfaction and he left to finance two movie short subjects on his savings and then to branch out into feature-length films with "Fear and Desire," a story of soldiers trapped behind enemy lines, and "Killer's Kiss," an action-thriller set in New York about a boxer who rescues his girl from a murderer. Meanwhile, he had become a motion picture cameraman member of the I.A.T.S.E. Local 644 in New York and served as his own Director of Photography on "Fear and Desire."

Critical recognition came with "The Killing" (1956) which he made in partnership with producer James B. Harris. "Paths of Glory" followed in 1957. A World War I story about a general who advances his career over the bodies of the men he sacrifices in action, it starred Kirk Douglas and Adolphe Menjou. Absolute realism distinguished its trench warfare scenes. Kubrick himself operated one of the cameras during the big attack that fanned across a hideously scarred and cratered no-man's-land.

His first taste of directing a large-scale Hollywood epic came with "Spartacus" (1960), the story of the Roman slaves revolt, which starred Kirk Douglas, Tony Curtis, Laurence Olivier, Peter Ustinov and Jean Simmons. Kubrick then narrowed his focus down to the individual again with the audacious sexual relationships of "Lolita" (1962). His sense of bizarre comedy assisted Vladimir Nabokov's screenplay in overcoming the obvious difficulties of the story.

With "Dr. Strangelove, Or How I Learned to Stop Worrying and Love the Bomb," he veered into nightmarish comedy. A view of the world through H-bomb sights, it starred Peter Sellers, George C. Scott and Sterling Hayden and won Kubrick acclaim from New York film critics as the best director of 1964.

Kubrick is a director who is inspired by facts the way other filmmakers are inspired by best-sellers. Facts suggested the theme of "2001: A SPACE ODYSSEY." Kubrick was struck by the new opportunities the space age opens to man, and with the possibility of contact with extra-terrestrial civilizations. To reinforce his passion for thorough research, the producer-director got the help of some of the world's biggest corporations to develop projects showing how their branch of work will look 33 years from now. Everything in the picture is a logical extension of current technology.

Kubrick works with a kind of abstracted absorption—a quietly controlled presence rather than a restless force. During filming of "2001: A SPACE ODYSSEY," he and his family lived in a spacious house in Hertfordshire, just outside London. The family includes his wife and three daughters. Mrs. Kubrick, the former German actress, Suzanne Cristane, played a role in "Paths of Glory," and on completion of the film, she and the director were married. All of Stanley Kubrick's motion pictures have been strikingly different. He has never repeated himself. After "2001: A SPACE ODYSSEY," the question is: What will he do for an encore?

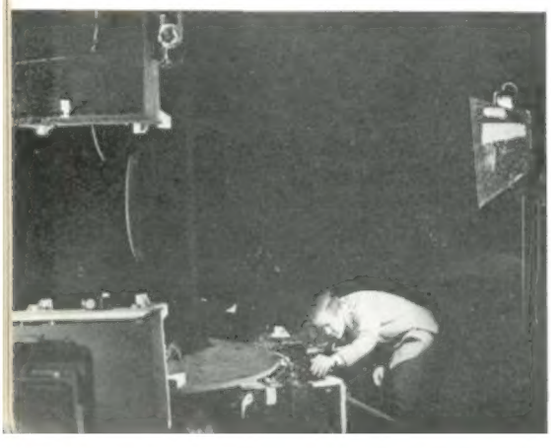
CREATING SPECIAL EFFECTS FOR 2001 A SPACE ODYSSEY

Do it right— then do it better— then do it all over again

By DOUGLAS TRUMBULL

"2001: A Space Odyssey" was an extremely complex and difficult film to make, and naturally there are many interesting stories connected with the production. Probably the most important aspect of the film is its special effects, and in this article I shall try to relate some of the specific problems encountered in a production of this type, some of the techniques we used to create the effects, and a few other interesting points about the production as a whole.

The author, Special Effects Supervisor Douglas Trumbull, making fine adjustments to the "Jupiter machine" built for "2001: A SPACE ODYSSEY."



One of the most serious problems that plagued us throughout the production was simply keeping track of all ideas, shots, and changes and constantly re-evaluating and updating designs, storyboards, and the script itself. To handle all of this information, a "control room," constantly manned by several people and with walls covered by pert charts, flow diagrams, progress reports, log sheets, punch cards, and every conceivable kind of filing system, was used to keep track of all progress on the film.

With a half-dozen cameras shooting simultaneously, some on 24-hour shifts, and different aspects of many sequences being executed at once, the problem of keeping apprised of each shot's progress was difficult at best. For the purpose of being able to discuss a shot without referring to a storyboard picture, each scene had a name as well as a number. For example, all scenes in the Jupiter sequence were named after football plays — "deep pass," "kickoff," "punt return," etc. Each of these terms called to mind a certain scene which related in some way to the name.

Early in production we began to realize that storyboards were useful only to suggest the basic scene idea, and as soon as a particular model or effect would come before the camera, something new would suggest itself and the scene would be changed. This change would often influence subsequent scenes. As each element of a shot was completed, a frame clip of the 35mm rush print would be unsqueezed and blown up to storyboard size with prints distributed to all of the people concerned. It was necessary to keep such an accurate record so that work could begin on other elements of the same shot. For example, each scene of the Discovery spacecraft required a different angle and speed of star movement, and a different positioning and action of the miniature rear-projected image in the cockpit.

All moving images in the windows of the various spacecraft were rear projected either at the time of photography of the model, although as a separate exposure, or later after the model image had been duped using Technicolor Yellow-Cyan-Magenta Masters, or "YCM's."

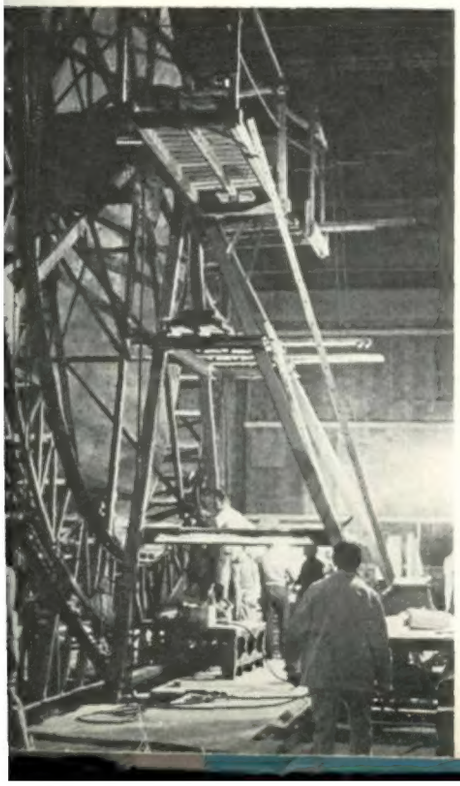
Astronauts mount ladder toward corridor that runs through the hub of the centrifuge. A smooth interchange of rotation between hub and corridor makes them appear to defy the law of gravity.

A few scenes show a miniature rear-projected image in the window of a spacecraft as the spacecraft is matted over an image of the moon. For this effect the foreground spacecraft was a still photograph mounted on glass and, using a bi-pack camera, the masters of the background image could be printed with a white backing behind the still photo — the photo silhouette producing its own matte. Then the photo and the rear-projected image could be shot as separate exposures onto the same negative. To produce exactly the same movement on each successive exposure, all movement drives and film advances were selsyn synchronized. The mammoth device designed to produce this effect we nicknamed the "Sausage Factory," because we expected the machine to crank out

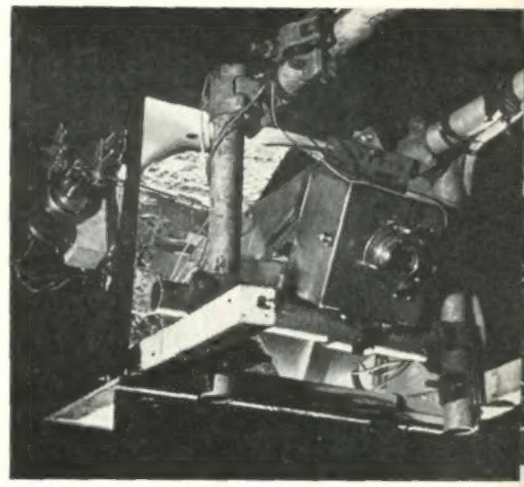
shots at a very fast rate. This turned out to be wishful thinking, however, and shooting became very painstaking and laborious work. Another drawback to printing masters in this way was the fact that lens flaring caused by the white backing would partially print the image within the silhouette. Therefore only very dark backgrounds could be used for these shots.

One of our first serious special effects problems presented itself during the live action shooting. The interior set of the *Orion* spacecraft (which flew from the earth to the space station) and the interior set of the *Aries* spacecraft (which flew from the space station to the moon) were both equipped with pinhole star backgrounds outside the windows. These backgrounds were made of thin sheet metal with each star individually drilled, and were mounted on tracks to produce an apparent motion from inside. As shooting began it became apparent that when the stars had the correct intensity in the 35mm printdown, they were much too bright in a 70mm print. And, when the stars looked correct in the 70mm version, they would disappear altogether in 35mm. So star brightness became a compromise, and after all the problems encountered in trying to accurately control star intensity on the set, almost all stars shot subsequent to those interiors were photographed on the animation stand.

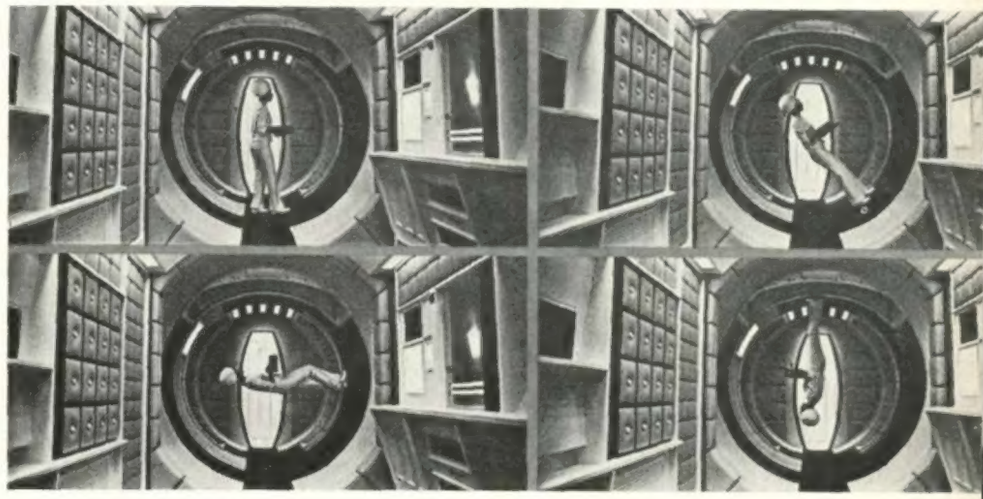
Exterior view of the giant centrifuge while under construction. It was 38 feet in diameter, approximately 20 feet wide on the outside, with about ten feet of free interior space.



The Oxberry animation stand equipped with a 65mm Mitchell camera was used for shooting backgrounds of stars, Earth, Jupiter, the Moon, as well as for rotascoping and shooting high contrast mattes. All stars shot on the animation stand were spatter-airbrushed onto glossy black paper backing and were shot at field sizes of from six to twenty-four inches wide. Extensive tests were made to find the optimum star speed for each shot and great care was taken to control the action so that the stars wouldn't strobe. In almost all shots it was necessary for the stars to be duped, but this became a simpler problem because they required only one record instead of the usual three YCM's.



Special 8 x 10 rotating plate projector on "Jupiter machine." Much of the equipment used had to be specially designed to solve unique problems.



Stewardess in space kitchen appears to walk upside down. Actually, the camera was securely locked down to the front part of the set, which rotated 180 degrees. Girl walked treadmill in rear portion of set, remaining upright at all times.

Backgounds of the Earth, Jupiter, Jupiter's moons, and others were back-lit Ektachrome transparencies ranging in size from 35mm to eight by ten inches, and these were shot from much larger painted artwork. The Moon was a series of actual astronomical glass plates produced by the Lick Observatory. These plates were used only after nearly a year of effort at the studio to build a moon model — several attempts, in fact, by different artists, and all were unsuccessful.

It may be noted that in only a few effects shots in space does one object overlap another. The reason for this is that normal matting techniques were either difficult or impossible to use. The rigging to suspend the models was so bulky and complex that the use of the blue screen technique would have been very awkward. Also, the blue screen would have tended to reflect fill light into the subtle shadow side of the white models. It became a monumental task merely to matte the spacecraft over the stars, and the final solution to this was meticulously rotascoped, hand-painted mattes.

Since we couldn't afford to tie up the animation stand, or any camera, for very laborious and time-consuming rotascope jobs on so many shots, a unique rotascoping system was devised. Using ordinary darkroom enlargers, equipped with carriers for rolls of 70mm film, each frame-by-frame image was projected onto specially marked animation peg boards, to which the projected image of the

ABOUT THE AUTHOR: *Douglas Trumbull was born in Los Angeles April 8, 1942. He studied engineering and architecture, and graduated from Morningside High School in 1960 with the intention of becoming an architect.*

After 1½ years at El Camino Jr. College, taking preliminary courses which included design, advertising, and painting, he became interested in illustration and began working as a free-lance technical illustrator.

Shortly after that he decided that animation might be more interesting and began showing his portfolio to studios in Hollywood. The Graphic Films Corp. was interested in some space illustrations he had done and hired him as an apprentice background artist. A year later he was earning the full journeyman rate as head of the Background Department.

At Graphic Films he worked on such films as "Lifeline In Space," for the U.S.A.F., "Space In Perspective" for N.A.S.A., and then "To The Moon and Beyond" in Cinerama 360 for the New York World's Fair. Stanley Kubrick saw this film, and after looking at some drawings he did for "2001" through Graphic Films, he was hired as one of a team of four Special Effects Supervisors (together with Wally Veevers, Con Pederson and Tom Howard) to work on the production in England.

His work began on "2001" in September of 1965 and included direction of the animation department producing all readouts, astronomical backgrounds of stars, earth, moon, Jupiter, etc., and all rotoscoped mattes. He organized and helped supervise the model detailing department and designed and supervised the photography of several moon terrain shots. In many cases, he built, articulated, detailed, and painted models himself, as well as supervising the lighting and photography. Working closely with Kubrick he jointly designed most of the interrelated movements of foreground and background, to produce the combined motion flow of models, live action, and animation. For the end sequence he designed and built the slit-scan device, with its hardware for completely automated and programmed shooting.

perforations had to be visually aligned.

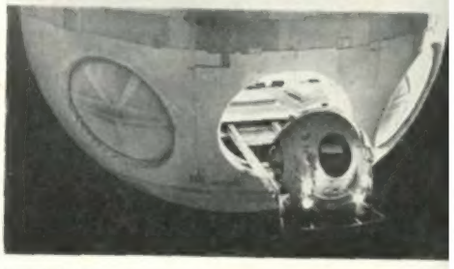
We found that a star could not be allowed to penetrate the edge of any spacecraft image even to the very slightest degree, although it was unnoticeable if the star was extinguished several frames before reaching that image. So to account for the poor tolerances in our visually registered system, each rotascoped cel was painted with a slightly oversized image.

All special effects work involves the standard problems of film steadiness, color correction, and matting, and "2001" was no exception. Since every effects shot necessitated the combining of multiple separate images onto one negative, absolute film steadiness was essential. After trying for months to find some rhyme or reason as to why some shots were steady and some weren't, we began the tedious task of comprehensive steady-tests on every roll of raw stock, every set of YCM's, and every roll of 35mm print-downs.

Another problem that gave us many headaches was the loss of black density due to multiple duped images being exposed onto one negative, and in a space film like "2001" the retention of blacks was very important. Part of this problem could be solved by ordering very dense sets of YCM masters to retain maximum contrast. Most original negatives were shot slightly over-exposed so that a higher printer light would be required to reproduce the image. This helped a little, but if carried too far would take the brilliance out of the whites. These precautions were only partially helpful and any shot involving more than two or three sets of masters would suffer a noticeable greying of the blacks.

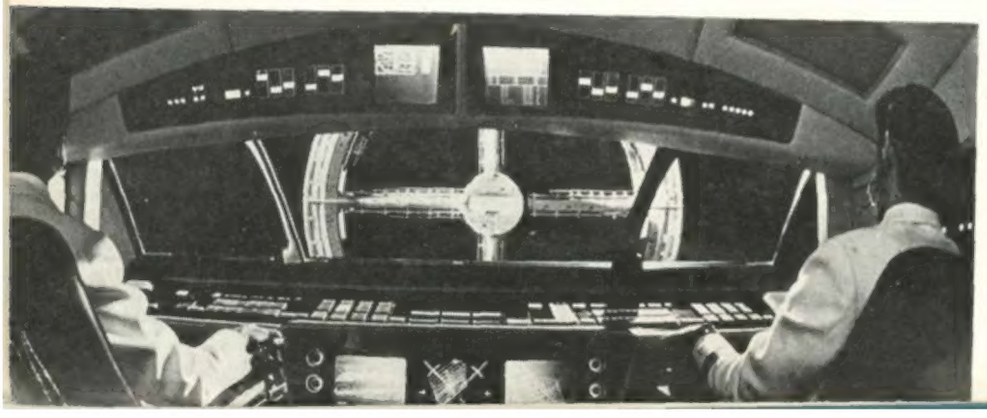
The solution was to make at least one element in the scene an original unduped image. Aside from helping to retain the blacks, an original image is naturally preferable to a duped one, and in many cases great pains were taken to keep all elements of an entire scene on the original negative.

The first live action shooting on "2001" took place in the giant moon excavation set built on Stage H at Shepperton Studios. The set itself only included a small portion of terrain at one end for the astronauts to walk on, so shots that included the complete Moon terrain, stars, and Earth, were held undeveloped for nearly a year until these other elements could be completed, tested, and then ex-



(TOP) "Discovery" spacecraft under construction, showing the beginning of detailing using parts from thousands of model kits. (BOTTOM) The completed 60-foot model discharging a one-man pod.

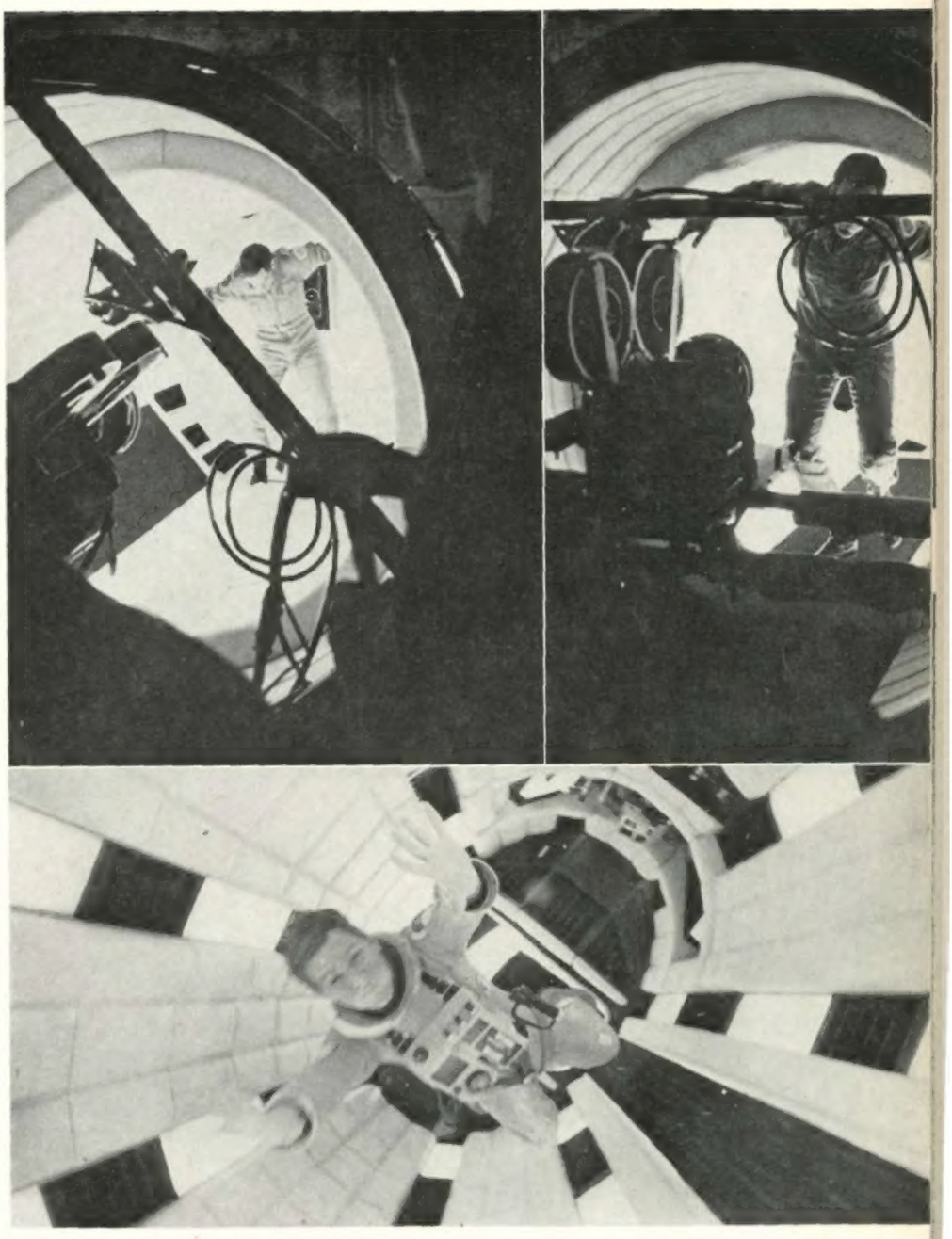
Interior view of the Orion commuter ship approaching the Space Station, with all of its scopes showing readouts. Preparation of these readouts for all of the spacecraft ate up tons of technical material and required many months to animate.



posed onto the held original negative.

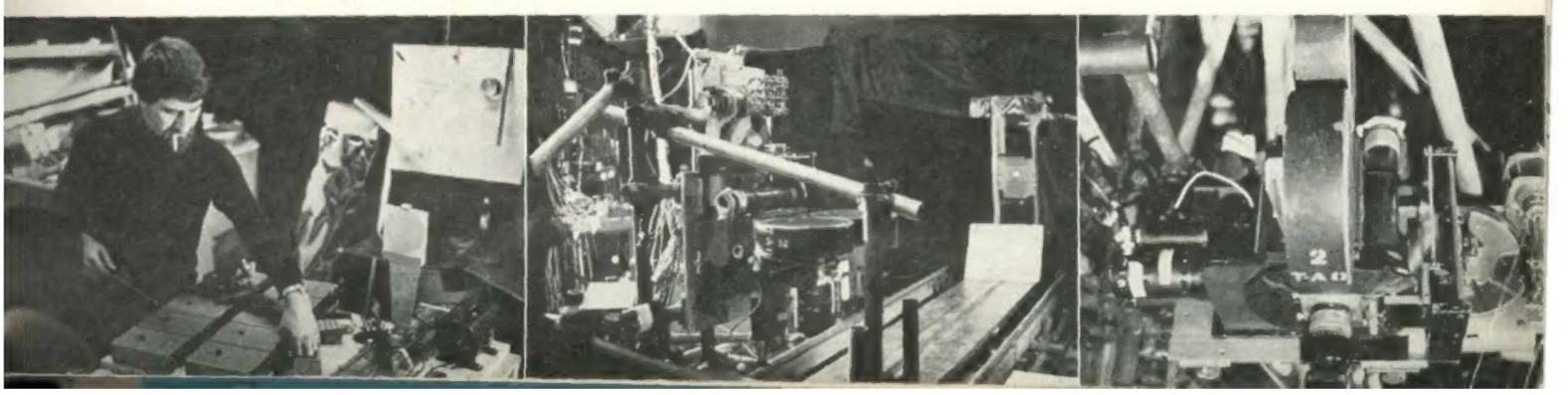
The "held take" shots at the Moon excavation were relatively simple compared to the held takes of moving live action miniature projections. Many shots required that a weightless, gyrating astronaut be moving through space, matted over the stars. For this effect, a 65mm shot of the astronaut was projected onto a small white card, and the camera moved relative to that card to produce the apparent motion. Since this miniature projection was already a form of duping, although it remained sharp and brilliant due to the extreme reduction in size, it was important that this image not go through a further dupe generation. In order to retain the miniature projection as a held take, four separate but identical takes would be shot, using the "Sausage Factory" selsyn system to retain absolute synchronization. Only one of these takes would be sent to the lab for processing, where a 35mm rush print would be made to check color and movement, and a 70mm print would be made so that the rotascoping process could begin. Later, the other duped elements of the shot and the matted stars would be exposed onto one of the held takes, still leaving two more takes to iron out any problems which might have arisen in the first "marry-up."

The models in "2001" are probably the most precisely detailed ever constructed for a film. As soon as the overall design was completed on each model, construction was begun to produce the basic form of that spacecraft, and this process often took several months. Then the arduous task of detailing and painting the model would begin. Massive crews of model detailers worked around the clock for several more months to produce



(TOP LEFT) Astronaut hangs vertically by wires with camera pointing directly upward. He is shown here at the top of his fall toward camera lens. (TOP RIGHT) Astronaut on wire at bottom, after falling toward the camera. (BELOW) The scene as it appears in the film, after he had blasted his way through the vacuum of space into an air-lock of the spacecraft.

(LEFT) Designer assembling a bank of photo-electric control devices for slit-scan mechanism. (CENTER) 65mm Todd-AO camera with follow-focus device mounted for operation of slit-scan set-up. (RIGHT) Todd-AO camera with Acme stop-motion motor and selsyn-driven follow-focus mechanism. The slit-scan technique, designed by the author, created the spectacular "psychedelic" sequence at the end of the film, in which the camera seems to be rushing thorugh endless geometrical corridors of color.



FRONT PROJECTION FOR

2001 A S ODY

An incredibly bright image on a huge screen lends tremendous scope to a limitless subject and adds an extra dimension to the art of film making

Perhaps the most significant single technique utilized in M-G-M's "2001: A SPACE ODYSSEY"—considered in terms of its potential value to the film industry as a whole — is Stanley Kubrick's extensive use of a completely new departure in the application of front-projection for background transparencies.

This advanced technology evolved out of the dramatic demands of his "Dawn of Man" prologue which called for hordes of ape-men to be shown against vast natural terrain backgrounds of primeval beauty. A perfect location in a remote area of Southwest Africa had been found and Kubrick was anxious to use this spectacular setting for his opening sequence.

"The geology in that area was completely different from anything else I'd seen," he explains. "The rocks didn't look like 'Bible' rocks and they didn't look like 'Western' rocks. They were really quite unique."

To capture this setting on film the way he envisioned it there were several options open to him. The first, most obviously, would have been to take a large cast and crew on location to the actual site. However, aside from the enormous cost involved, the company would most likely have found itself at the mercy of inclement and ever-changing weather.

Another obvious alternative would have been the use of a painted backdrop, which, in this case, would have had to be 40 feet high and 110 feet wide. The main drawback was not the size, but rather the fact that such backdrops all too often look like exactly what they are.

In theory, the blue-screen matting system could have been used, or even a king-size adaptation of the standard rear-projection process method. In actual practice, however, each of these approaches, applied on such a vast scale, might not have produced quite the illusion of reality which the director hoped to achieve.

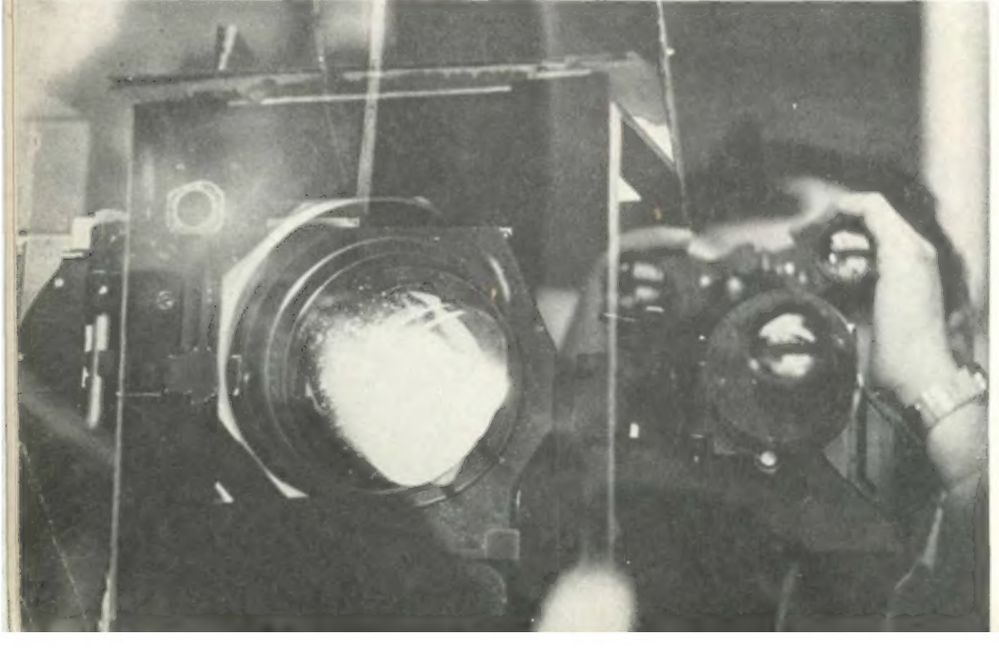
He elected, instead, to use front-projection on a scale never before attempted. The front-projection concept is not, in itself, new. The method has, in fact, been in practical use for several years, mainly by still photographers and in television studios. It had not, however, up until now, been used to any great extent in the motion picture industry.

The largest format utilized to date had been a 4 x 5-inch Ektachrome transparency, but it was felt that the grand-scale requirements of this particular space epic would demand an even larger transparency.

"I had made a test using a 4 x 5 still and it was almost good enough, so I was positive that with an 8 x 10 the effect would be perfect," Kubrick comments. "The trickiest part would be balancing the foreground illumination to match the intensity of the front-projected background. Now that it's over I'm convinced that if a still transparency is to be used for the background scene an 8 x 10 is essential, because if you don't have a surplus of resolution you are going to get a degradation, of the projected background image."

The only drawback at the time was

On the set of "2001: A SPACE ODYSSEY," producer-director Stanley Kubrick uses binoculars to check fine focus on the vast front-projection screen. Special 3M material reflects 100 times the light falling upon the screen, provided that projector and film camera lenses are aligned on precisely the same axis. Kubrick wanted to use an 8 x 10 transparency for maximum sharpness, found there was no projector for it in existence, built his own.



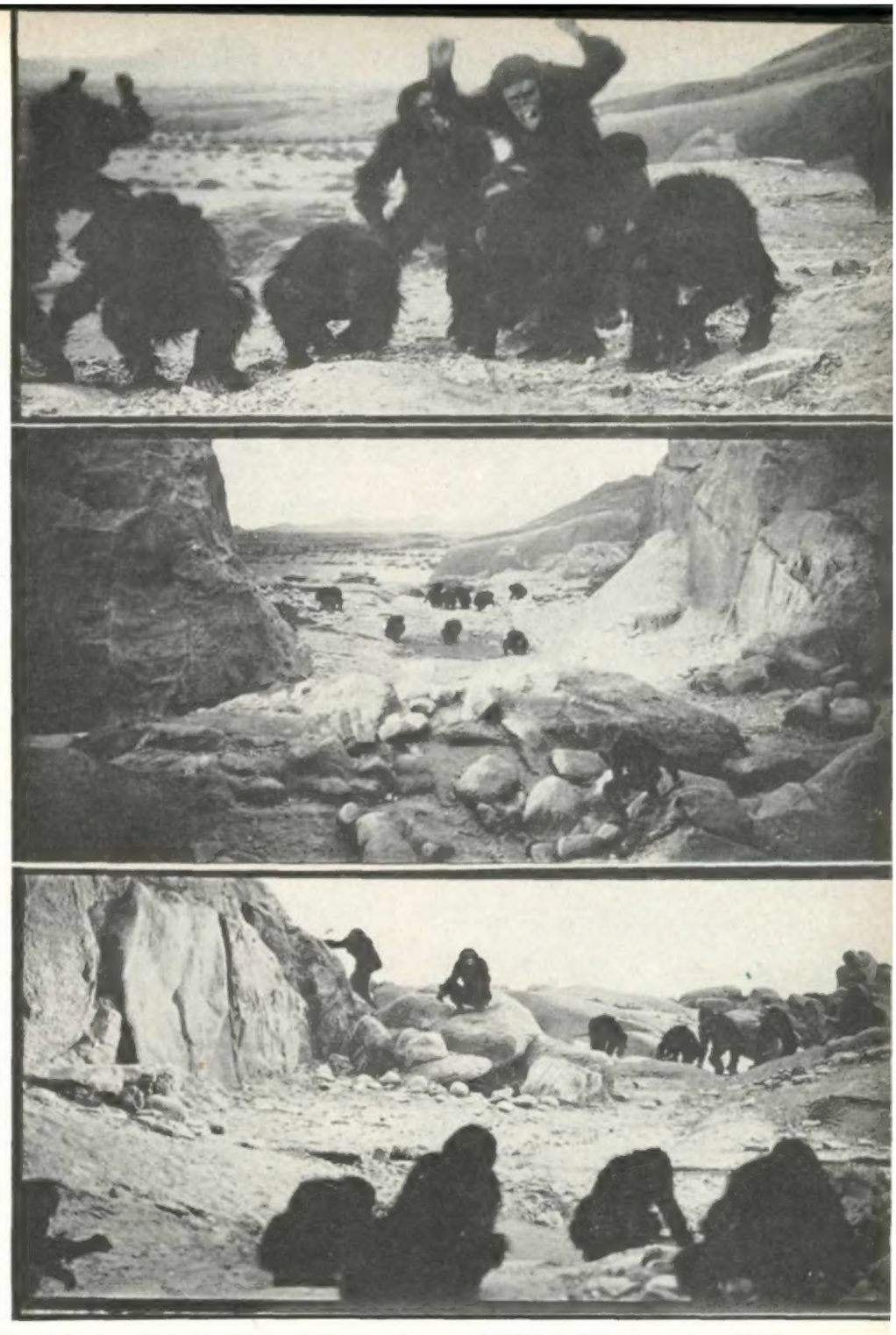
that there existed no such device as an 8 x 10 projector—let alone one powerful enough to throw a bright image across 90 feet of foreground area onto a screen 110 feet wide. Working in close cooperation with M-G-M Special Effects Supervisor Tom Howard, Kubrick set about building his own super-powerful 8 x 10 projector, with a condenser pack 18 inches thick made up of condensers from standard 8 x 10 enlargers. The most powerful water-cooled arc available was employed as a light source and it was necessary to use slides of heat-resistant glass in front of the condensers in order to prevent the heat from peeling the magenta layer of emulsion right off of the transparency. At least six of the rear condensers cracked because of the heat during the filming, but this was usually due to a draft of cold air hitting the projector when someone opened the door of the sound stage while the projector was operating.

In order to conserve the transparencies as much as possible, the projector was only turned on during the one to five minutes at a time needed to make an actual take with the camera. For purposes of aligning the equipment a reject plate was used. Since any dust or dirt appearing on the surface of the plate would be magnified on the giant screen many times and become clearly apparent, the most careful precautions had to be taken. Anti-static devices were used and the plates were loaded under "antiseptic" conditions. The operator who loaded plates into the projector used editing gloves, and even wore a surgical mask so that his breath would not fog the mirror.

In aligning the camera-projector configuration for front-projection the projector was set up at right angles to the camera with the projected image beamed onto a partially-silvered 36-inch-wide mirror mounted at a 45° angle about eight inches in front of the camera lens. The camera photographed through the mirror, the front surface of which bounced the projected image onto the screen. A heavy steel rig with micrometer adjustment was engineered to assure the very critical alignment between camera and projector in order that there would be no possibility of "fringing." A nodal camera head made it possible to pan across the mirror in scenes where the camera lens was fielding a composition that included less than the full screen.

A key requirement in front-projection is that the camera and projector be so precisely aligned that, in terms of physics, the projected light source and the center of the camera lens are located at the same point. Or, in more graphic terms, as if the light source were inside the camera. This is essential because of the peculiar uni-directional reflectivity of the screen material used, which produces a phenomenal gain in brilliance — but only when projected light is reflected directly back to its source.

The surfacing material used for the giant screen was a special 3M fabric



Frame blow-ups from the "Dawn of Man" prologue to "2001" indicate the scope of background that can be achieved on the sound stage. Kubrick recommends the 8 x 10 size transparency for maximum sharpness. M-G-M is now building a 65mm front projector with a frame 20 sprocket holes wide so that moving backgrounds on a large scale can be used.

As astronaut enters a different time and space dimension near Jupiter, bright colors flash across his visor. These were actually reflections from pod instrument panel, filmed at 12 frames-per-second.

Behind the scenes, a fine mix of genius and determination. (LEFT) Special Effects Supervisor Con Pederson works on perliminary design sketches for "Discovery" spacecraft. (Center) Kubrick stews over photographic problem with Cameraman John Alcott. (RIGHT) Special Effects Supervisor Wally Veevers rigs thin nylon wires to create weightless food tray effect on Ariesinterior set.

In pod-bay set, Kubrick mulls one of the many thousands of technical problems that beset him during production of space epic.

coated with very tiny mirrored beads of glass. It has the incredible capability of reflecting 100 times the amount of light that is projected onto it, so that, theoretically, if the light falling onto the screen gave an incident light reading of 1 foot-candle, the light reflected back to the camera would measure 100 foot-candles.

This special lenticular 3M material comes in rolls and an effort was made to surface the screen by mounting it in 100-foot strips. However, because of a slight variation in reflectivity between rolls, seams were frequently visible under projected light. An attempt to match strips exactly proved unsuccessful, so the material was finally torn into small, jagged, irregular shapes which were mounted in a "camouflage" mosaic, shape on top of shape, so that there was no longer any visible variation in reflectivity.

It is natural that certain obvious questions should come to mind in relation to the front-projection technique.

Firstly, since the projected image is falling upon the foreground subject *as well* as upon the screen in the background, why is that projected image not at least partially visible spilling onto the foreground subject—particularly in view of the fact that such a subject is much closer to the camera than the background screen? The answer is that exposure of the entire scene must be gauged to the extremely brilliant image reflected from the screen and which, because of the incredible reflectivity of the 3M screen material, is 100 times brighter than any light image reflected from the foreground subject. This would pertain even if the foreground subject were a person wearing a silver suit; he would still show up on the film as a black figure silhouetted against the brilliant background image. Even though the faint image falling upon the foreground subject might be dimly visible to someone present on the set, it would be too faint for the film to "see"—because there simply does not exist an emulsion with a wide enough latitude to accommodate such an extreme brightness contrast range. In addition, a tremendous amount of light is needed to balance the foreground subject with the extremely bright image reflected from the screen. This light would effectively "wash out" any residue of front-projected image falling upon the foreground subject.

The second question that might logically be asked is: Why aren't the shadows of foreground objects visible on the background screen? The answer is that, since the light source and the camera lens are precisely aligned on a common axis, the foreground subject exactly "fits" its own shadow, covering it completely. So perfect is the match that even if a front-projected closeup were made

Camera operator on front-projector rig had to wear surgical mask to keep from fogging the semi-silvered mirror. Heat of projector was so intense that the draft from a door opening on the stage sometimes cracked the condensers.

FILMING "2001: A SPACE ODYSSEY"

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and a galaxy of magnificently hued starbursts. Finally, he steps from the one-man pod into a lavish living-bedroom suite that boasts a luminous floor and Louis XVI furniture. He sees himself aging progressively until, as a very ancient senior citizen he reaches out in supplication toward the by-now-familiar monolith which stands at the foot of his bed.

The last sequence in the film shows a "starchild" embryo with glowing eyes which seems to emerge from the fusion of planets to go soaring through space in cosmic concert with the monolith.

The Behind-the-scenes Of A Great Film Adventure

Knowing of the air-tight security which had attended filming of the special effects for this production, I was a bit apprehensive about asking Stanley Kubrick to discuss the intricate technology involved.

However, in my lengthy discussion with him (an occurrence which some journalists might aptly refer to as an "exclusive interview"), I found him to be completely cooperative. He answered my questions fully and often volunteered additional information, seeming actually eager to share his considerable know-how with the professional film-makers who constitute the great majority of the AMERICAN CINEMATOGRAPHER readership.

I had heard about the elaborate "command post" which had been set up at Borehamwood during the production of "2001." It was described to me as a huge, throbbing nerve center of a place with much the same frenetic atmosphere as a Cape Kennedy blockhouse during the final stages of Countdown.

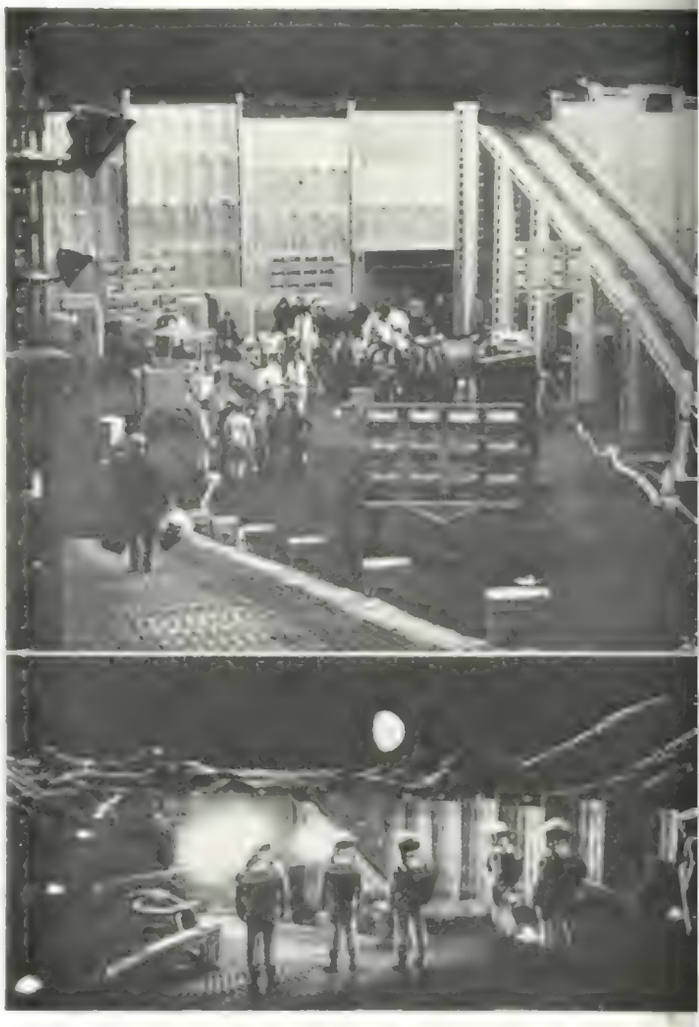
"It was a novel thing for me to have such a complicated information-handling operation going, but it was absolutely essential for keeping track of the thousands of technical details involved," Kubrick explained. "We figured that there would be 205 effects scenes in the picture and that each of these would require an average of 10 major steps to complete. I define a 'major step' as one in which the scene is handled by another technician or department. We found that it was so complicated to keep track of all of these scenes and the separate steps involved in each that we wound up with a three-man sort of 'operations room' in which every wall was covered with swing-out charts including a shot history for each scene. Every separate element and step was recorded on this history—information as to shooting dates, exposure, mechanical processes, special requirements and the technicians and departments involved. Figuring 10 steps for 200 scenes equals 2,000 steps—but when you realize that most of these steps had to be done over eight or nine times to make sure they were perfect, the true total is more like 16,000 separate steps. It took an incredible number of diagrams, flow-charts and other data to keep everything organized and to be able to retrieve information that somebody might need about something someone else had done seven months earlier. We had to be able to tell which stage each scene was in at any given moment—and the system worked."

The Ideal Of The "Single-generation Look"

A film technician watching "2001" cannot help but be impressed by the fact that the complex effects scenes have an unusually sharp, crisp and grain-free appearance—a clean "single-generation look," to coin a phrase. This is especially remarkable when one stops to consider how many separate elements had to be involved in compositing some of the more intricate scenes.

This circumstance is not accidental, but rather the result of a deliberate effort on Kubrick's part to have each scene look as much like "original" footage as possible. In following this pursuit he automatically ruled out process shots, ordinary traveling matte shots, blue-backings and most of the more conventional methods of optical printing.

"We purposely did all of our duping with black and white, three-color separation masters," he points out. "There were no color inter-positives used for combining the shots, and I think this is principally responsible for the lack of grain and the high degree of photographic quality we were able to maintain. More than half of the shots in the picture are dupes, but I don't think the average viewer would know it. Our separations were made, of course, from the original color negative and we then used a number of bi-pack camera-printers for combining the material. A piece of color negative ran through the gate while, contact-printed onto it, actually in the camera,



(TOP) Vast excavation of the moon crater Tycho was dug on the huge Stage H of London's Shepperton studios. (BELOW) The excavation as it appears in the finished film, complete with astronauts, miniature moon mountains and the Earth shining in the background. Lunar landscape was a model artfully devised to simulate the real thing, and was printed in later.

were the color separations, each of which was run through in turn. The camera lens 'saw' a big white printing field used as the exposure source. It was literally just a method of contact printing. We used no conventional traveling mattes at all, because I feel that it is impossible to get original-looking quality with traveling mattes."

Smooth Trips For Star-voyagers

A recurring problem arose from the fact that most of the outer-space action had to take place against a star-field background. It is obvious that as space vehicles and tumbling astronauts moved in front of these stars they would have to "go out" and "come back on" at the right times—a simple matter if conventional traveling mattes were used. But how to do it a better way?

The better way involved shooting the foreground action and then making a 70mm print of it with a superimposed registration grid and an identifying frame number printed onto each frame. The grid used corresponded with an identical grid inscribed on animation-type platens.

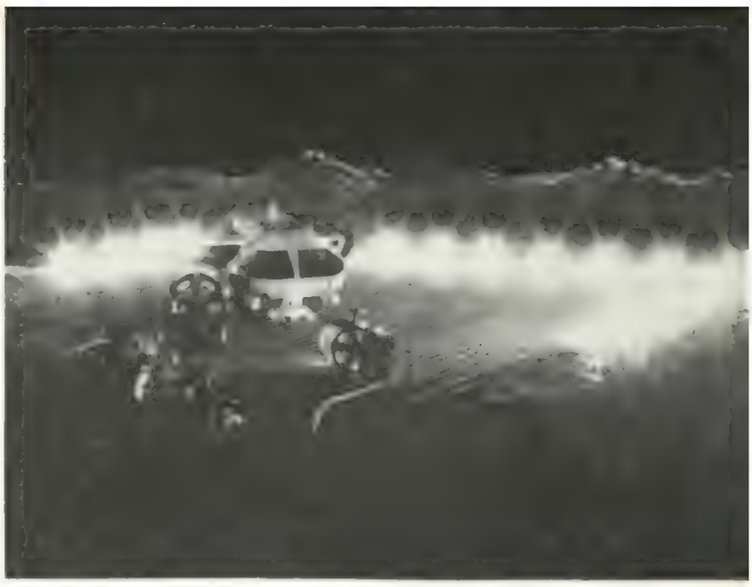
Twenty enlargers operated by twenty girls were set up in a room and each girl was given a five or six-foot segment of the scene. She would place one frame at a time in the enlarger, line up the grid on the frame with the grid on her platen and then trace an outline of the foreground subject onto an animation cel. In another department the area enclosed by the outline would be filled in with solid black paint.

The cels would then be photographed in order on the animation stand to produce an opaque matte of the foreground action. The moving star background would also be shot on the animation stand, after which both the stars and the matte would be delivered to Technicolor Ltd. for the optical printing of a matted master with star background. Very often there were several foreground elements, which meant that the matting process had to be repeated for each separate element.

The Mechanical Monster With The Delicate Touch

In creating many of the effects, especially those involving miniature models of the various spacecraft, it was usually necessary to make multiple repeat takes that were absolutely identical in terms of camera movement. For this purpose a camera animating device was constructed with a heavy worm-gear 20 feet in length. The large size of this worm gear enabled the camera mount of the device to be moved with precise accuracy. A motorized head permitted tilting and panning in all directions. All of these functions were tied together with selsyn motors so that moves could be repeated as often as necessary in perfect registration.

For example, let us assume that a certain scene involved a fly-by of a spaceship with miniature projection of the interior action visible through the window. The required moves would be programmed out in advance for the camera animating device. A shot would then be made of the spaceship miniature with the exterior properly lighted, but with the window area blacked out. Then the film would be wound back in the camera to its sync frame and another identical pass would be made. This time, however, the exterior of the spacecraft would be covered with black velvet and a scene of the interior action would be front-projected onto a glossy white card exactly filling the window area. Because of the precision made possible by the large worm gear and the selsyn motors, this exact



Moon Bus miniature on landing pad inside lunar crater is shown surrounded by 650-watt quartz "landing lights" which blaze directly into the lens. Moonscape was only a few feet wide, but built in forced perspective to create an effect of vast distance.

dual maneuver could be repeated as many times as necessary. The two elements of the scene would be exposed together in perfect registration onto the same original piece of negative with all of the moves duplicated and no camera jiggle.

Often, for a scene such as that previously described, several elements would be photographed onto held-takes photographed several months apart. Since light in space originates from a sharp single point source, it was necessary to take great pains to make sure that the light sources falling on the separate elements would match exactly for angle and intensity.

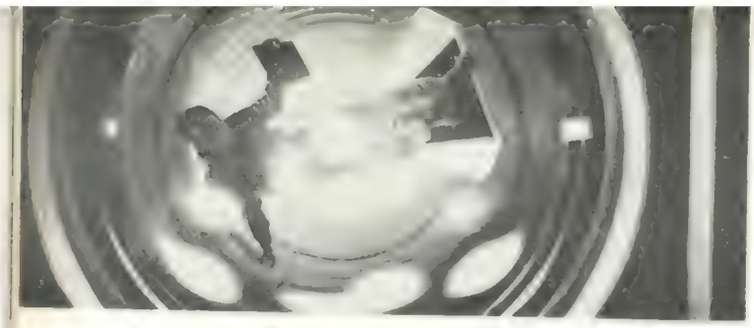
Also, since the elements were being photographed onto the same strip of original negative, it was essential that all exposures be matched precisely. If one of them was off, there would be no way to correct it without throwing the others off. In order to guard against this variation in exposure very precise wedge-testing was made of each element, and the wedges were very carefully selected for color and density. But even with all of these precautions there was a high failure rate and many of the scenes had to be redone.

"We coined a new phrase and began to call these 're-don'ts'," says Kubrick, with a certain post-operative amusement. "This refers to a re-do in which you don't make the same mistake you made before."

Filming the Ultimate in Slow Motion

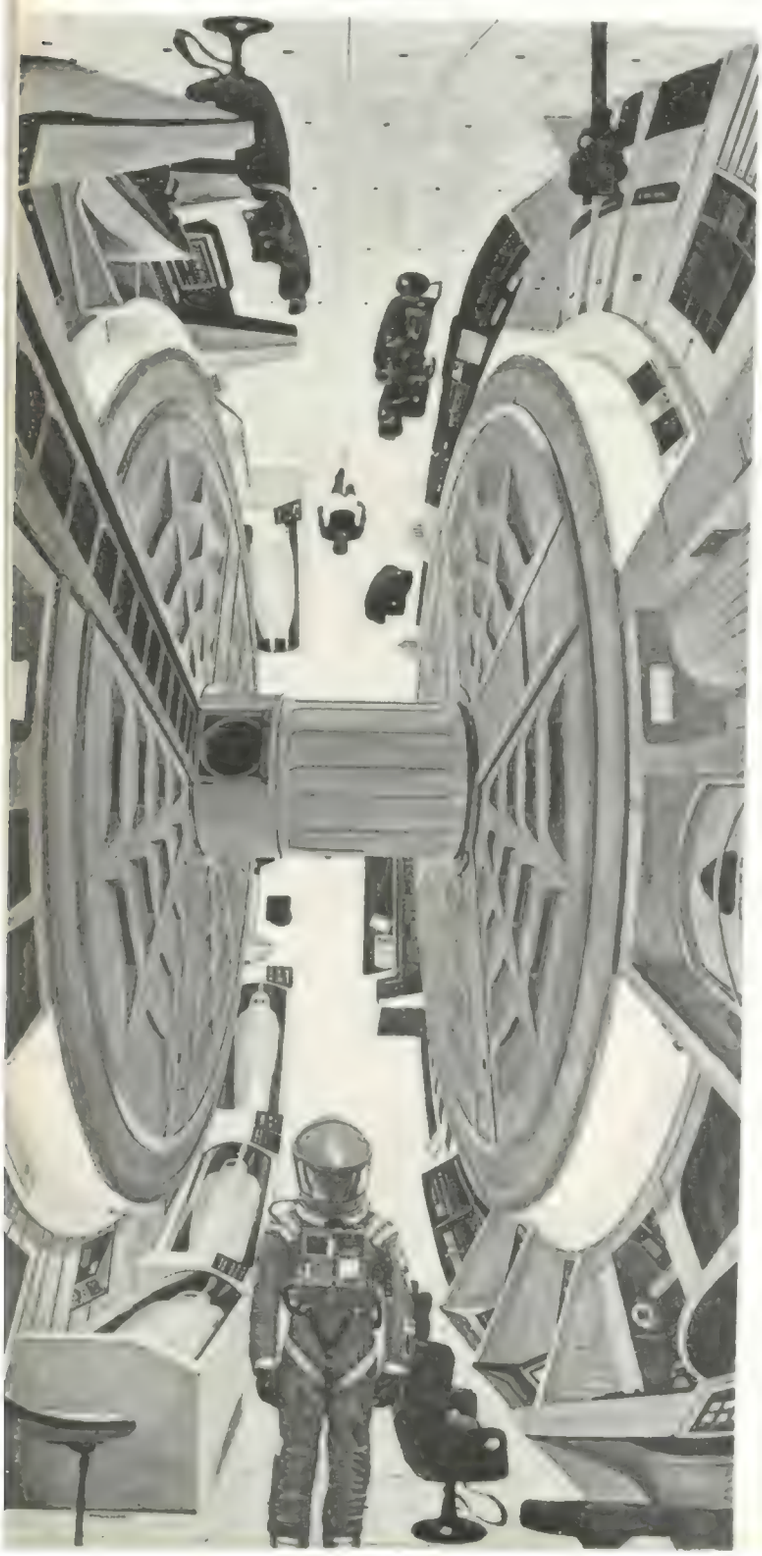
In the filming of the spacecraft miniatures, two problems were encountered which necessitated the shooting of scenes at extremely slow frame rates. First, there was

A one-man pod hovers above port of the mother ship Discovery. Spherical front section of this 60-foot model was six feet in diameter and was crowded with rear-projection equipment to flash window images of astronauts inside the compartment.



A computer's-eye-view of an astronaut presenting artwork for inspection. Subjective point-of-view from inside the computer was achieved with Fairchild "bugeye" type extreme wide-angle lens covering a field of almost 180 degrees.

Artist's rendering of the giant centrifuge set built for the film by the Vickers-Armstrong Engineering Group, at a cost of $750,000. 38 feet in diameter, it revolved at a rate of 3-miles-per-hour. In this scene a space-suited astronaut stands in the foreground while his partner does roadwork upside down.



the matter of depth-of-field. In order to hold both the forward and rear extremities of the spacecraft models in sharp focus, so that they would look like full-sized vehicles and not miniatures, it was necessary to stop the aperture of the lens down to practically a pin-hole. The obvious solution of using more light was not feasible because it was necessary to maintain the illusion of a single bright point light source. Secondly, in order to get doors, ports and other movable parts of the miniatures to operate smoothly and on a "large" scale, the motors driving these mechanisms were geared down so far that the actual motion, frame by frame, was imperceptible.

"It was like watching the hour hand of a clock," says Kubrick. "We shot most of these scenes using slow exposures of 4 seconds per frame, and if you were standing on the stage you would not see anything moving. Even the giant space station that rotated at a good rate on the screen seemed to be standing still during the actual photography of its scenes. For some shots, such as those in which doors opened and closed on the space ships, a door would move only about four inches during the course of the scene, but it would take five hours to shoot that movement. You could never see unsteady movement, if there was unsteadiness, until you saw the scene on the screen—and even then the engineers could never be sure exactly where the unsteadiness had occurred. They could only guess by looking at the scene. This type of thing involved endless trial and error, but the final results are a tribute to M-G-M's great precision machine shop in England."

It's All Done With Wires — But You Can't See Them

Scenes of the astronauts floating weightlessly in space outside the *Discovery*—and especially those showing Gary Lockwood tumbling off into infinity after he has been murdered by the vengeful computer — required some very tricky maneuvering.

For one thing, Kubrick was determined that none of the wires supporting the actors and stunt men would show. Accordingly, he had the ceiling of the entire stage draped with black velvet, mounted the camera vertically and photographed the astronauts from below so that their own bodies would hide the wires.

"We established different positions on their bodies for a hip harness, a high-back harness and a low-back harness," he explains, "so that no matter how they were spinning or turning on this rig—whether feet-first, head-first or profile—they would always cover their wires and not get fouled up in them. For the sequence in which the one-man pod picks Lockwood up in its arms and crushes him, we were shooting straight up from under him. He was suspended by wires from a track in the ceiling and the camera followed him, keeping him in the same position in the frame as it tracked him into the arms of the pod. The pod was suspended from the ceiling also, hanging on its side from a tubular frame. The effect on the screen is that the pod moves horizontally into the frame to attack him, whereas he was actually moving toward the pod."

To shoot the scene in which the dead astronaut goes spinning off to become a pin-point in space took a bit of doing. "If we had actually started in close to a six-foot man and then pulled the camera back until he was a speck, we would have had to track back about 2,000

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FRONT PROJECTION

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was provided by covering almost the entire ceiling of the sound stage with a total of 1500 RFL-2 lamps.

"Each of these lamps had its own individual switch so that we could maintain very delicate control of the foreground lighting," Kubrick points out. "This was necessary not only in order to match it with the background lighting, but also because the height of the set varied. In some areas the 'hills' were closer to the ceiling than the surrounding terrain. The individual switches made it possible to turn off any one light all by itself and to literally *shape* the light to the contours of the set. We could do this very, very quickly and with the greatest flexibility."

While Brute arcs with straw-colored gels in front of them were used to provide a hint of modeling and relieve the basically flat effect, no attempt was made to create a strong point source suggesting direct sunlight.

"There's simply no really effective way to realistically simulate a single light source when you're shooting such a huge area in a high lighting key," Kubrick explains, "but if you're shooting for an effect of cloudy weather or spotty sunlight, you can match it perfectly to the background. And that kind of lighting looks better anyway, in my opinion, than full, direct, 'Kodak Brownie' sunlight."

The ghostly night scenes in the "Dawn of Man" sequence were photographed by using basically the same techniques that are routinely employed for shooting day-for-night exteriors in the true outdoors—namely, a couple of stops of under-exposure and printing through a light blue filter.

One stunning effect that invariably brings gasps from the audience was achieved quite unexpectedly and may be regarded as a sort of "bonus" to the production. During the prologue a lithe leopard is seen moving among the rocks. As the big cat turns its head full into camera its eyes seem literally to light up with a brilliant, fluorescent orange glow. The impact is startling.

"A happy accident," shrugs Kubrick. "I can only conjecture that the cat's eyes must contain some substance having a reflectivity similar to

Continued on Page 456

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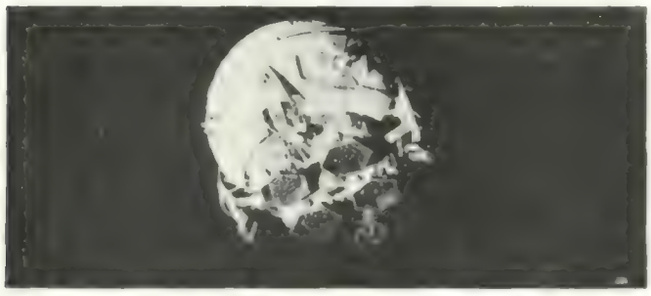
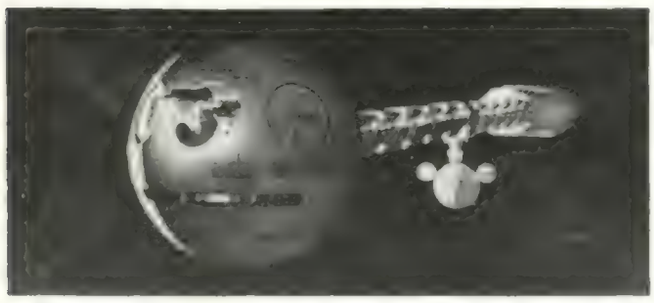
Orion, a sleek, delta-winged aerospace plane whisks commuters between Earth and a space station orbiting several hundred miles out.

Space Station Five, a rotating spoked wheel supposedly 1,000 feet in diameter was actually an 8-foot miniature with air-cooled lights inside.



Aires, a globular vehicle which carries passengers from the space station to the Moon has retractible legs that extend for landing.

The Moon Bus which zooms between the lunar base headquarters and the crater Clavius, is nostalgic of early Buck Rogers spacecraft.



Giant space-voyager Discovery, represented as 600 feet long, was actually built to 1/10th scale. The fleet of highly detailed beautifully articulated spacecraft took a model-building crew many months to construct.

FILMING "2001: A SPACE ODYSSEY"

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feet—obviously impractical," Kubrick points out. "Instead we photographed him on 65mm film simply tumbling about in full frame. Then we front-projected a six-inch image of this scene onto a glossy white card suspended against black velvet and, using our worm-gear arrangement, tracked the camera away from the miniature screen until the astronaut became so small in the frame that he virtually disappeared. Since we were re-photographing an extremely small image there was no grain problem and he remained sharp and clear all the way to infinity."

The same basic technique was used in the sequence during which the surviving astronaut, locked out of the mother ship by the computer, decides to pop the explosive bolts on his one-man pod and blast himself through the vacuum of space into the air-lock. The air-lock set, which appears to be horizontal on the screen, was actually built vertically so that the camera could shoot straight up through it and the astronaut would cover with his body the wires suspending him.

First a shot was made of the door alone, showing just the explosion. Then an over-cranked shot of the astronaut was made with him being lowered toward the camera at a frame rate which made him appear to come hurtling horizontally straight into the lens. The following shot was over-cranked as he recovered and appeared to float lazily in the air-lock.

A Fascinating Ferris Wheel

"2001: A SPACE ODYSSEY" abounds in unusual settings, but perhaps the most exotic of them all is the giant centrifuge which serves as the main compartment of the *Discovery* spacecraft and is, we are told, an accurate representation of the type of device that will be used to create artificial gravity for overcoming weightlessness during future deep-space voyages.

Costing $750,000, the space-going "ferris wheel" was built by the Vickers-Armstrong Engineering Group. It was 38 feet in diameter and about 10 feet in width at its widest point. It rotated at a maximum speed of three miles per hour and had built into it desks, consoles, bunks for the astronauts and tomb-like containers for their hibernating companions.

All of the lighting units, as well as the rear-projectors used to flash readouts onto the console scopes, had to be firmly fixed to the centrifuge structure and be capable of functioning while moving in a 360° circle. The magazine mechanisms of the Super-Panavision cameras had to be specially modified by Panavision to operate efficiently even when the cameras were upside down.

"There were basically two types of camera set-ups used inside the centrifuge," Kubrick explains. "In the first type the camera was mounted stationary to the set, so that when the set rotated in a 360° arc, the camera went right along with it. However, in terms of visual orientation, the camera didn't 'know' it was moving. In other words, on the screen it appears that the camera is standing still, while the actor walks away from it, up the wall, around the top and down the other side. In the second type of shot the camera, mounted on a miniature dolly, stayed with the actor at the bottom while the whole set moved

past him. This was not as simple as it sounds because, due to the fact that the camera had to maintain some distance from the actor, it was necessary to position it about 20 feet up the wall—and have it *stay* in that position as the set rotated. This was accomplished by means of a steel cable from the outside which connected with the camera through a slot in the center of the floor and ran around the entire centrifuge. The slot was concealed by rubber mats that fell back into place as soon as the cable passed them."

Kubrick directed the action of these sequences from outside by watching a closed-circuit monitor relaying a picture from a small vidicon camera mounted next to the film camera inside the centrifuge. Of the specific lighting problems that had to be solved, he says:

"It took a lot of careful pre-planning with the Lighting Cameraman, Geoffrey Unsworth, and Production Designer Tony Masters to devise lighting that would look natural, and, at the same time, do the job photographically. All of the lighting for the scenes inside the centrifuge came from strip lights along the walls. Some of the units were concealed in coves, but others could be seen when the camera angle was wide enough. It was difficult for the cameraman to get enough light inside the centrifuge and he had to shoot with his lens wide open practically all of the time."

ed as a prime example of the auteur approach to film-making—a concept in which a single creative artist is, in the fullest sense of the word, the *author* of the film. In this case, there is not the slightest doubt that Stanley Kubrick is that author. It is *his* film. On every 70mm frame *his* imagination, *his* technical skill, *his* taste and *his* creative artistry are evident. Yet he is the first to insist that the result is a group effort (as every film must be) and to give full credit to the 106 skilled and dedicated craftsmen who worked closely with him for periods of up to four years.

Among those he especially lauds are: screenplay co-author Arthur C. Clarke, Cinematographers Geoffrey Unsworth and John Alcott, and Production Designers Tony Masters, Harry Lange and Ernie Archer. He also extends lavish praise to Special Effects Supervisors Wally Veevers, Douglas Trumbull, Con Pederson and Tom Howard.

The praise, it would seem, is not all one-sided. M-G-M's Post-production Administrator Merle Chamberlin worked with Kubrick for a total of 20 weeks, both in London and in Hollywood, on the final phases of the project. A man not given to rash compliments, Chamberlin has this to say of the endeavor: "Working with Stanley Kubrick was a wonderful experience—a tremendously pleasant and educational one. He knows what he wants and how to get it, and he will not accept anything less than absolute per-

MACHINE MURDERS MAN IN SPACE! The one-man pod, egged on by neurotic computer, grabs unsuspecting astronaut in its metallic arms, kills him and flings him into space. In order to operate arms it was necessary to have a team of ten men working levers in closest co-ordination at a control console. Separate technicians each controlled fingers, hands, forearms, etc. Both the astronaut and the pod were suspended from black velvet-draped ceiling with camera shooting up vertically so that wires supporting them would be concealed. Astronaut used a variety of harnesses to change body position, required bottled oxygen to breathe, and was moved toward pod on overhead track. In the film the pod appears to be doing the moving as it attacks him.

Cinematographer Unsworth used an unusual approach toward achieving his light balance and arriving at the correct exposure. He employed a Polaroid camera loaded with ASA 200 black and white film (because the color emulsion isn't consistent enough) to make still photographs of each new set-up prior to filming the scene. He found this to be a very rapid and effective way of getting an instant check on exposure and light balance. He was working at the toe end of the film latitude scale much of the time, shooting in scatter light and straight into exposed practical fixtures. The 10,000 Polaroid shots taken during production helped him considerably in coping with these problems.

"Film-making" In The Purest Sense Of The Term

To say that "2001: A SPACE ODYSSEY" is a spectacular piece of entertainment, as well as a technical *tour de force*, is certainly true, but there is considerably more to it than that.

In its larger dimension, the production may be regard-

fection. One thing that surprised me is his complete lack of what might be called 'temperament.' He is always calm and controlled no matter what goes wrong. He simply faces the challenge with incredible dedication and follows it through to his objective. He is a hard taskmaster in that he holds no brief for inefficiency—and it has been said that he knows nothing of the proper hours for sleeping—but he is a fantastic film-maker with whom to work. I have been privileged to work very closely with David Lean on 'DOCTOR ZHIVAGO,' with John Frankenheimer on 'GRAND PRIX,' with Michelangelo Antonioni on 'BLOW-UP' and with Robert Aldrich on 'THE DIRTY DOZEN'—all terrific people and wonderful film-makers. But as a combination of highly skilled cinema technician and creative artist, Kubrick is absolutely tops."

From my own relatively brief contact with the creator of "2001: A SPACE ODYSSEY" I would say that this praise is not over-stated, for Stanley Kubrick, Film Author, epitomizes that ideal which is so rare in the world today: Not merely "Art for the sake of Art"—but vastly more important, "Excellence for the sake of Excellence." ■

EASTMAN FILMS

Continued from Page 426

new film used in the same circumstances, the aperture would be set at f/5.6. The picture exposed with Type 5251 should be in sharp focus between eight and 13 feet. With the new film, exposed under the same conditions, the area of sharpness is between seven and a half feet and 15 feet.

Increased depth of field, however, is only a part of the story of what the new color negative film should mean to motion picture productions crews. It also offers an opportunity for cameramen to shoot on-location scenes earlier in the morning, later at night and in bad weather. Since the film is faster, you can translate the added speed into an ability to work with less light for more realistic location coverage.

Thus, those motion pictures that count upon a true depiction of the early morning hours and/or dusk for the sake of reality can now more safely be considered for color film. The same is true for location-made, rainy day scenes. This is a particularly significant change when you recall that only a short while ago certain types of dramatic scenes required the use of a black-and-white film. The implications reach all the way to the story development level: Because of the increased speed of the new negative color film, script writers will be able to call for scenes that were previously impossible to realistically achieve in color.

In television there are many production situations where you may want to take advantage of the faster film speed by opening your aperture wider. Cost savings could be substantial. The loss in depth of field which would be evident on a theatrical screen, of course, would be less obvious viewed over the television system.

A related advantage to the lower lighting power requirements, of course, is the fact that actors and actresses will be able to work under lower lighting levels which naturally will radiate less heat.

In the end it could mean less actor and actress fatigue, fewer makeup changes, and thus more efficient shooting schedules and better performances. For these reasons alone, theatrical producers might be tempt-

Continued on Page 466

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"2001" SPECIAL EFFECTS

Continued from Page 419

the finished results. Basic construction was of wood, fiberglass, plexiglass, steel, brass, and aluminum. The fine detailing was made up of specially heat-formed plastic cladding, flexible metal foils of different textures and thicknesses, wire, tubing, and thousands of tiny parts carefully selected from hundreds of every conceivable kind of plastic model kit, from boxcars and battleships to airplanes and Gemini spacecraft. A delegation from the production was sent to an international model exhibition in Germany to select the best kits available.

Every minute facet of each model had to be perfect, so that photography would not be restricted in any way, and during shooting the cameras came relentlessly close with no loss of detail or believability.

Each spacecraft was built to a scale which best suited that particular model, without any particular regard to scale relationship between models. Only the *Discovery* spacecraft and the pod were on the same scale, since they had to work so closely together. Very tricky calculating had to be done for the approach of the *Orion* spacecraft to the space station because both models couldn't be built to the same scale. Roughly, the *Orion* was three feet long, the space station eight feet in diameter, the *Aries* two feet in diameter, the Moon rocket-bus two feet long, and the *Discovery* fifty-four feet long with a thirteen-inch diameter pod. The main "command module" ball of *Discovery* was six feet in diameter, and for long shots another complete model of *Discovery* was built to a length of fifteen feet. All moving parts on the models were motor driven and extremely geared-down since most shooting was at a very show rate due to the necessity for stopping down to small lens apertures to obtain maximum depth-of-field.

The Moon terrain models required considerable depth-of-field also, and in order to keep the distance from foreground to infinity within a focusable range, they were built with extremely forced perspective. Detail was graduated from very large foreground rocks and rubble to tiny mountain peaks and plains on the horizon in a total actual depth of about five feet. To reproduce in model form exactly what a drawing re-

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Selsyn driven, rotating plate projectors mounted on "Jupiter machine" rig.

As the black monolith vanishes into a strangely symmetrical alignment of Jupiter and its moons, the camera pans up and the "Stargate" engulfs the screen. For this infinite corridor of lights, shapes, and enormous speed and scale, I designed what I called the Slit-Scan machine. Using a technique of image scanning as used in scientific and industrial photography, this device could produce two seemingly infinite planes of exposure while holding depth-of-field from a distance of fifteen feet to one and one-half inches from the lens at an aperture of F/1.8 with exposures of approximately one minute per frame using a standard 65mm Mitchell camera.

After the Stargate, there follows a series of fantastically delicate, apparently astronomical cataclysms. The images implied exploding stars, vast galaxies, and immense clouds of interstellar dust and gas. Without revealing too much detail, I'll merely say that these effects involved the interactions of certain chemicals within a camera field of a size no larger than a pack of cigarettes.

The final series of shots before Keir Dullea ends up in his unusual predicament were done by shooting some fairly unusual aerial scenes, and then juggling the color filters in the YCM duping process. It took months of experimentation to find the key to this technique.

The live action sequences in

BEHIND THE CAMERAS

Continued from Page 400

WALTER LASSALLY: "The Adding Machine"; color, shooting in England.

PIETRO PORTALUPI, ASC: "The Story of a Woman"; color, shooting in Italy.

WILLIAM CLOTHIER: "The Hellfighters"; Technicolor and Panavision, shooting in Houston.

WILLIAM MARGULIES, ASC: "An Angel In My Pocket", Technicolor.

ELLSWORTH FREDRICKS, ASC: "Wylie", Technicolor.

GERRY FISHER: "Secret Ceremony", color, shooting in London.

Walt Disney

EDWARD COLMAN, ASC: "The Love Bug". Technicolor.

Warner Brothers

CLAUDE RENOIR: "The Madwoman of Chaillot"; A Commonwealth United Corp. Film Prods., Technicolor, shooting in Nice.

LUCIEN BALLARD: "The Wild Bunch"; Panavision and Technicolor, shooting in Mexico.

PHILIP LATHROP, ASC: "The Illustrated Man"; Technicolor.

ARTHUR GRANT: "Dracula Has Risen From the Grave", Hammer-Warner-7 Arts; color, Widescreen, shooting at Pinewood, London.

BILL BUTLER: "The Rain People", Widescreen, Technicolor, cross-country shooting schedule.

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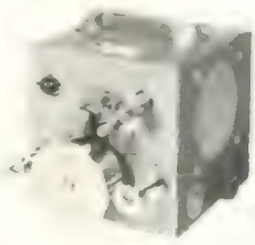

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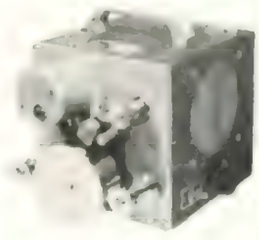

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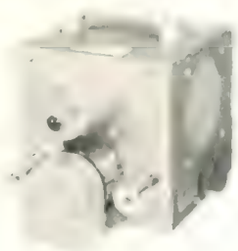

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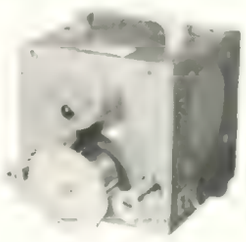

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"2001" involved so many different trick sets, rear projections, and stunts, that the only approach to writing about them is to handle each in the order in which it occurs in the film.

Filming of the "Dawn of Man" sequence took place entirely on only one stage at the studio. Distant backgrounds for all the action were front-projected eight-by-ten Ektachrome transparencies, using probably the largest front-projection device ever made, and constructed specially for "2001." The projector consisted of a specially intensified arc source with water-cooled jaws to hold the oversized carbons, special heat-absorbing glass, giant condensing lenses which would occasionally shatter under the intense heat, special eight-by-ten glass plate holders and positioning mounts, an extremely delicate semi-silvered mirror, and a specially built nodal point head so that the camera could pan, tilt, and zoom without fringing of the image.

To camouflage the varying light transmission rates between rolls of the front projection screen material on the giant 40- by 90-foot screen, the material was cut up into small, irregular pieces and pasted up at random so that slight variations in the transmission rates would merge with cloud shapes or be lost altogether in brilliant sunlight effects. Since the screen occupied an entire wall of the stage, and the front-projection rig was delicate and cumbersome, the sets were built on a giant rotating platform which covered most of the stage floor. Widely varying camera angles could then be obtained with no movement of the screen, and little movement of the projection rig.

During the testing of this front-projection system, it was found that the intense light and heat being poured through the transparency would burn off layers of emulsion in a matter of minutes. Additional heat filters were installed but the only real solution was to expose the plate only during the critical moments that the camera was running. Duplicate plates were used for various line-ups, tests, and rehearsals. Even with such an intense light source, the long throw from projector to screen required lens apertures of around F/2.

The first live action shots in the space sequence took place on board the *Orion* spacecraft during its journey to the space station. For long

Continued on Page 459

ROSTER OF FESTIVALS

Continued from Page 455

matter of film classifications and bring about clearer definitions as to how films should be classified. This becomes increasingly more important as the number of film entries grows and pre-screening sessions must be held. Pre-screening by film classifications or groups of subject matter is about the only way such a task can be accomplished.

Association members are also currently considering a method of exchanging lists of film-makers so that a wider group of them can be made aware of the various festivals around the world.

Another suggestion soon to be presented to the group is a system of merit awards to be given to top filmmakers, possibly on some international basis, but this may be a year away.

Most important of all, the Association has brought the sponsors of amateur film festivals closer together in their thinking, and through correspondence they have been able to meet one another and exchange common problems.

One of the most important problems the Association hopes to solve, or at least to ease to some degree, is the matter of often strict customs regulations. Some countries allow comparative freedom to films coming into the country for the purpose of entering a film festival, subsequently to be returned to their makers, while other countries will hold up a film for a week or more to determine if it is in any way objectionable. Some countries charge a small duty on such films, even though they are merely being loaned for cultural purposes and will be returned to their owners within a few weeks.

Headway on this problem is slow and will require patience and endurance, but it is a good example of the tough problems the Association is facing and shows what is being done and what will be done through the alliance of the amateur film festivals of the world.

Officers of the Association consist of a President and a Vice-President. The terms are for two years, and no officer can succeed himself. The two officers cannot reside in the same country. The president, if he wishes, may appoint a secretary.

Each member festival appoints one of its staff to serve as a representative to the Association, and through this representative the member festival casts its vote in Association affairs. The officers are elected from this group of festival representatives. Current president is George W. Cushman, FPSA, of the U.S.A. Vice-president is Roy D. Charlton of Australia.

The purpose, as written in the Association's Constitution, best sums up the aims of the organization and is as follows: "... to stimulate participation in amateur film festivals, to unify rules and regulations thus eliminating confusion in the minds of the contestants, to cooperate with member festivals and assist in solving common problems, and to maintain the highest possible ideals in conducting film festivals."

Inquiries pertinent to the activities of the Association should be addressed to: International Association of Amateur Film Festivals, Box 4034, Long Beach, California, USA, 90804. ■

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FRONT PROJECTION

Continued from Page 445

that of the 3M material used on our screen, because the eyes picked up the front-projected light and reflected it almost as brightly as the screen itself."

In order to utilize the full scope of the front-projection screen, the normal shooting combination paired a 75mm lens on the film camera with a 14-inch lens on the 8 x 10 projector. However, it was possible, by "cheating" a bit, to record scenes with an even wider scope. This was accomplished by using a 50mm lens on the camera and extending the sides of the composition beyond the limits of the screen with foreground elements such as a boulder or a river bank.

There is no doubt that the superlative quality of the front-projection sequences in "2001: A SPACE ODYSSEY" will lead to a widespread adoption of the technique within the film industry. "In my opinion it will revolutionize what we used to call 'transparency photography' because of its great flexibility and scope," comments M-G-M Post-production Administrator Merle Chamberlin. "Because it affords the capability of projecting a sharp, clear background onto such a huge screen, it will be possible to achieve tremendous production value at a relatively low cost. You can create almost any locale quite realistically right on the sound stage, and march a whole army through it if you choose—in one door of the stage and out the other."

Already the process is being used in the production of another M-G-M super-spectacle, "WHERE EAGLES DARE," which is currently shooting in London, and Special Effects expert Tom Howard is adapting it to the use of moving backgrounds by devising a special 65mm motion picture movement that will accommodate a frame 20 sprocket holes wide. This movement will transport the film horizontally (much in the manner of VistaVision) and will make possible the front-projection of a very large and clear motion picture scene to be used as a background.

If for no other reason than this, the production of "2001" might be considered a cinematic milestone — but there are a great many more reasons! ■

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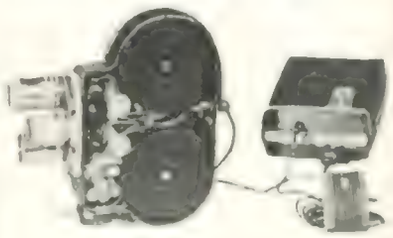

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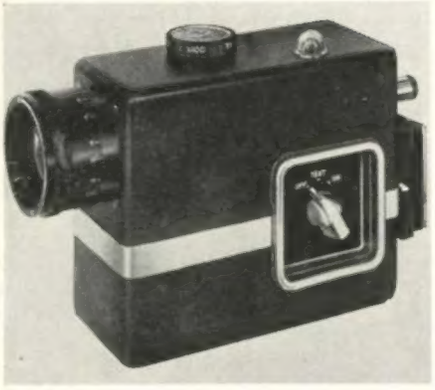
WHAT'S NEW

Continued from Page 407



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Victor Animatograph Corporation, a division of The Kalart Company, Inc., Plainville, Connecticut, has announced the addition of a new Zoom Lens accessory for its models 65, 70, 70-MC3 and 75 Series 16mm sound motion picture projectors.

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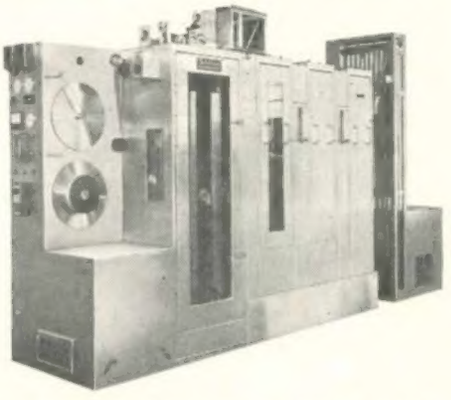

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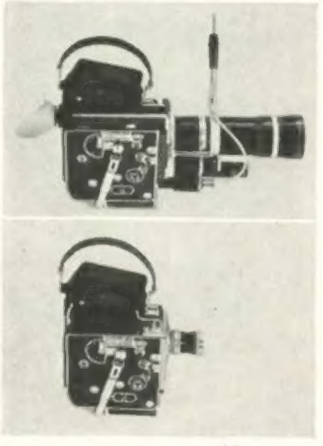

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"2001" SPECIAL EFFECTS

Continued from Page 454

shots of the apparently weightless floating in mid-air, the pen was simply suspended on thin monofilament nylon strands. For the close-up reverse angle shots the entire end of the set was floated away, and an eight-foot diameter rotating glass was moved into position with the pen lightly glued to it. The stewardess merely had to pluck it off.

The movie being shown on the TV set in front of the sleeping passenger was a little more complicated. Kubrick wanted shots of a futuristic car, and close-ups of a love scene taking place inside. A crew was dispatched to Detroit to shoot a sleek car of the future which was provided by, I believe, the Ford Motor Company. The exteriors were shot in 35mm, but the interiors were shot without seats or passengers, as four-by-five Ektachrome transparencies. Using these as background plates for a normal rear-projection set-up, an actor and actress were seated in dummy seats and Kubrick directed the love scene. Shot on 35mm, this was cut together with the previous exterior shots, and projected onto the TV screen using a first-surface mirror.

In the cockpit of the *Orion* spacecraft, during its approach to the space station we begin to see a few of the 35mm animated, rear-projected computer displays on multiple screens. Throughout the space sequences these displays depict the activities of computers on board the *Orion*, *Aries*, Moon Rocket Bus, *Discovery*, and Pod spacecraft.

To produce thousands of feet of continually changing graphic readouts to cover the multitude of screens in "2001" would have been an impossibly long job using ordinary animation techniques. We terminated work with the local animation camera service, set up our own 35mm Mitchell camera with stop-motion motor, and with the help of a very talented and artistically oriented cameraman, we began the job of pasting up and juggling around artwork under the camera as we were shooting. In this way sometimes as much as a thousand feet of active, colorful, diagram animation could be produced in one day. Specific readouts showing docking alignments taking place, testing procedures under way, and other specific story points were not as fast and easy to shoot, however, and

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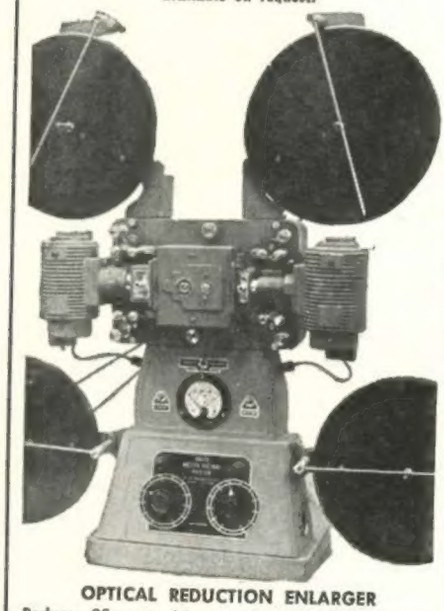

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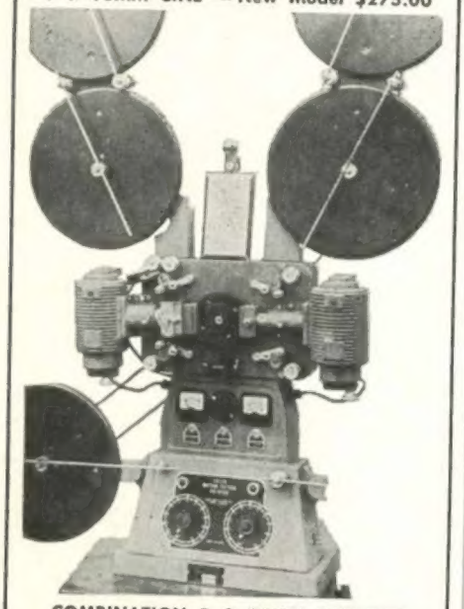

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the job of producing all of the read-outs for "2001" took nearly a year.

The interior of the space station was a giant curved set over three hundred feet long, and sloping up at one end to nearly forty feet. It may be noticeable that in the long shot of two men approaching the camera from the far end, their pace is slightly awkward, and this was due to the very steep slope at that end of the set. Most action took place in the more comfortable area at the bottom. The Earth image seen through the window of the space station was a rear-projected four-by-five transparency in a special rotating mount.

Aboard the *Aries* spacecraft on its trip to the moon, in the passenger compartment a stewardess is watching another TV screen, and again the action was directed and edited by Stanley Kubrick. The galley scene of this spacecraft where the stewardess comes in, picks up a tray, and then walks up the wall to exit upside down, was filmed using a rotating set with all lights and the camera secured to the rotating structure. The stewardess merely remained upright as the set and camera rotated around her.

The *Discovery* spacecraft included the most exciting sets of the production, and the most spectacular of these was the giant centrifuge. At a cost of over $750,000 the massive forty-foot diameter structure could rotate like a ferris-wheel. With the actors either standing, walking, or even running at the bottom of the set, cleverly thought-out camera angles made it appear that the actors could stand upright at any angle around the circular set.

In one of the most difficult shots Gary Lockwood was strapped into his seat and had to hang upside-down pretending to eat glued-down food while Keir Dullea climbed down the ladder at an angle 180 degrees opposed to Gary. As Keir began to walk around the centrifuge toward Gary, the centrifuge was slowly rotated until Keir and Gary were together at the bottom. The camera, which was locked down to the centrifuge floor, was then at the top. For other shots the camera was mounted on a specially made 360-degree tilting platform which was bolted to the floor of the centrifuge, and the camera operator sat in a ferris-wheel type seat which kept him upright at all times. Other shots were done with the camera mounted on a small rubber-tired dolly,

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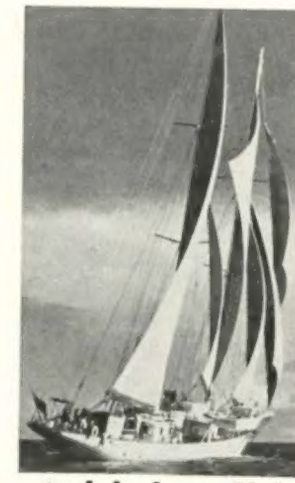

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which would be pulled by grips frantically clambering up the inside of the centrifuge as it rotated, trying to keep ahead of an actor shadow boxing at the bottom.

All lights and large banks of 16mm projectors also rotated with the set, so that exploding bulbs, loose junk, and reels of film constituted a serious hazard to people nearby. Hard hats had to be worn by everyone involved, and the control area from where the centrifuge was driven, and action directed by closed-circuit television, was netted over with chicken wire and heavy plastic.

The cylindrical corridor which linked the hub of the centrifuge to the rest of the ship, was constructed of two separately rotating sections, with the camera mounted securely to the corridor end. With the hub end rotating, the actors could walk down the static corridor and then step onto the hub as the port came to a position at the bottom. As soon as they stepped across onto the hub, it would stop and the corridor would begin to rotate in the opposite direction. From the camera's point of view the apparent rotation remained constant, but the actors seemed to be completely defying the law of gravity.

Other apparently weightless effects, which took place during the excursions outside the spacecraft, and in the "Brain Room," were created by suspending the astronaut on wires and then shooting from directly below so that he would cover his own means of support.

Several versions of the full-sized pod were used during the *Discovery* sequence. Three dummy pods were used in the pod-bay, two of which had operational doors, but only roughly mocked-up interiors. A separate interior pod set was built which included all the instrumentation, controls, and readout displays. Finally, a full-sized pod was built with completely motorized, articulated arms. It took ten or twelve men at long control consoles to simultaneously control the finger, wrist, forearm, elbow, and shoulder actions of the two pod arms, and the interior of that pod was a maze of servos, actuators, and cables.

Possibly one of the most unusual aspects of the live action photography on the interior sets of "2001" is that almost all lighting was an actual integral part of the set itself, and additional lighting was used only for critical close-ups. ■

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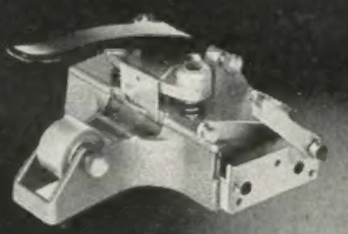

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